Testing EcoDriver training in Australian conditions

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1 Introduction

Due to Australia's large land mass and relatively small, highly urbanised population, road transport is of critical importance. Compared with most other countries, Australia has high freight levels and road lengths per capita. Australia's truck fleet travels around 12,500 million km and transports some 1,549 million tonnes of freight per year. In Australia, road transport accounts for 14% of anthropogenic CO_2-e emissions (Department of Climate Change – DCC, 2008a) with commercial trucks accounting for about 36 per cent of those road transport related emissions (DCC, 2008b).

Greenhouse gas emissions from road vehicles depend on a number of factors, with both design (supply-side) and use (demand-side) elements. Societal actions largely determine demand-side factors. In considering how to respond to environmental concerns such as global warming and pollution, society typically must weigh competing goals. Actions related to road transport aimed to address climate change are no exception. The range of available societal actions that could be drawn upon to reduce emissions includes infrastructure funding, regulatory environment, economic incentives/disincentives, and support for research and development.

On the supply side, there is the potential to influence vehicle fuel efficiency not only by the type of vehicles purchased, but through how those vehicles are operated. The driver is critically important in determining how the vehicle is operated and consequently has a considerable influence on fuel consumption and emissions. Of particular interest in the context of the research reported here is the scope to provide training to drivers to reduce fuel consumption and emissions. Often known as EcoDriving, this approach has gathered momentum in Europe but has not been systematically explored in an Australian setting.

This project grew out an Industry Action Agenda developed by the Australian Cement Industry in conjunction with the Commonwealth Government (Department of Industry Tourism and Resources – DITR, 2006) which in part sought to improve energy efficiency and the industry's greenhouse record. For the cement industry in Australia, the diversified location and nature of raw materials and energy sources, the quality and quantity of transport infrastructure, and the distribution of markets all result in logistics being a critical issue. Road transport dominates, particularly for transport of cement from plants/depots to customers where 90 per cent travels by road. Each year in Australia, approximately 15 million tonnes of cement is transported by road, equating to about 1% of all road freight carried.

The role of driver training was explicitly mentioned in the Industry Action Agenda. Subsequently, funding from Sustainability Victoria (a state government agency) and the Cement Industry Federation (CIF) enabled the research reported here to be undertaken. The primary objective of this project was to develop, conduct and evaluate a pilot EcoDriver training program aimed at reducing fuel consumption of heavy commercial vehicles involved in the cement industry. The project was a collaborative exercise. Drivers from a CIF member company undertook training provided by an independent driver training company. The evaluation was also carried out independently.

The structure of this paper is as follows. Section 2 identifies the key characteristics of EcoDriving and summarises international experience with the EcoDriver training programs. The field trial and its results are then discussed in Section 3. The final section of the paper (Section 4) presents the conclusions of this study and outlines future directions for this research.

2 International experience with EcoDriver training

EcoDriver programs have existed in Europe for a number of years with research and development efforts there receiving funding from the European Commission's Director General of Energy and Transport. Eco-driving is usually regarded as involving:

- Shifting up through the gears as soon as possible with the exact advice varying for shift up between 2000 and 2500 rpm (EcoDriven, 2006),
  before 2000 - 2500 rpm (Treatise UK, 2007),
  before 2500 rpm for petrol/LPG cars,
  before 2000 rpm for diesel cars, and
  before 1500 rpm for trucks (Bon Beter Leefmilieu, 2008)

- Maintaining a steady speed in the optimal engine speed range (1200-3000 rpm)

- Using the highest gear possible and driving with low engine rpm

- Anticipating traffic flow, looking ahead as far as possible and anticipating surrounding traffic, avoiding strong accelerations, full throttle and long idling (EcoDriven, 2006; Ford Motor Company, 2008)

- Decelerating smoothly

- Monitoring and maintaining appropriate tyre air pressures.

In relation to the issue of tyre inflation, tyre pressures which are 25% too low have been reported to increase rolling resistance by 10% and fuel consumption by 2% (Treatise UK, 2007).

In addition, EcoDriver training often includes some additional tips regarding:

- Driving uphill
- Reducing idling through considering when to start and switch off the engine
- Negotiating bends
- Carrying unnecessary weight in the vehicle
- Dealing with aerodynamics
- Making smart use of in-car devices, particularly the air conditioner.

A review of the literature on EcoDrive initiatives in Europe highlighted that many documents provide only limited explanatory information behind the results that are presented. The general procedures followed in the European Eco-drive evaluations are not reported in detail, although af Wåhlberg (2007b) provides an overview and Quality Alliance EcoDrive and Swiss Energy (2004) describe a series of Eco-drive evaluations conducted in Switzerland before 2003. The evaluation procedure reported in the Swiss work consists of an Eco-drive training and a post-training evaluation. Each training session lasted at most one day and some training included practice using vehicles or simulators or a combination of the two. In some cases, the evaluation was conducted immediately after the training; while in some other cases, the evaluation was conducted a few months or a couple years later to address medium/long-term effects of the Eco-drive training. Some evaluations were conducted "longitudinally", i.e. with respect to the same group of drivers but comparing their driving performance before and after the training; on the other hand, some evaluations were done cross-sectionally, i.e. the comparison was made between groups of people with and without Eco-drive training.

The major performance indices considered for the Eco-drive evaluation are fuel consumption and Eco-drive ratio. The Eco-drive ratio is defined as speed divided by fuel consumption.

According to Quality Alliance EcoDrive and Swiss Energy (2004), samples of between 20 and 100 individuals typically participate in the driver training. Most examples identified focus on passenger cars, while there are fewer examples of Eco-driving being applied to trucks (Bon Beter Leefmilieu, 2008; Holcim, 2005).

The evaluation results which are reported in the literature highlight the variability in the results with reported average fuel consumption reductions ranging as follows:

- 12-25% (Quality Alliance EcoDrive and Swiss Energy, 2004),
- 20% immediately after the training and 5% in the long run (EcoDriven, 2006)
- 8.5% after 2-hour training (UK), 7% in the long run (the Netherlands); 13.4% (Spain); 5.8% (Germany) (Treatise UK, 2007)
- Up to 10% for cars and 5-7% for trucks (Belgium) (Bon Beter Leefmilieu, 2008)
- Up to 20% (Ford Motor Company, 2008)
- 8.5% for trucks (Holcim, 2005)
- 10-15% for buses (Zarkadoula *et al*., 2007)
- 4% for buses (af Wåhlberg, 2007a).

As noted above, much of the EcoDriver material relates to passenger cars and there is much less discussion of the application of an EcoDriver training approach to heavy vehicle drivers. The potential benefits in terms of fuel saved from more efficient driving would be greater on a per-driver basis for heavy vehicles given the number of kilometres such a driver would cover on an annual basis, though from the point of view of greenhouse gas emissions and total emissions car drivers represent a better target. Holcim (2005) describes a trial that involved a one-day training session for 8 to 12 people. Performance was measured before and after the training (on the same day). The average reduction in fuel consumption was about 8.5% while the average speed around the 30 km test circuit increased by about 9%. Thus rather than taking longer, the adoption of the EcoDriving style enabled the drivers to complete the circuit driver quicker. In addition, the fuel consumption reduction was found to be still 5.6% after 7 months.

The limited information available on Eco-Drive evaluations has resulted in concerns being expressed in the literature about the rigour of the reported evaluation results. af Wåhlberg (2007b) argues that:

> *The claims regarding the Eco-drive benefits were mainly made by educators and bureaucrats, and lack scientific backing. More specifically, no literature on Eco-drive was found after a thorough literature search in major academic databases covering transport, energy, and psychology.*

Taken as a whole, the literature suggests little doubt about the benefits of the Eco-drive, but the major uncertainty lies in the quantitative aspect, i.e. the extent of the Eco-drive benefit and the degree of statistical significance that can be attached to those results. This highlights the need for rigorous evaluation. Other issues identified in the literature review, which are of relevance to future research, include:

- The credibility of the short-term Eco-drive benefits, especially where these are based on simulator-based evaluations conducted immediately after the training.

- The relationship between short-term and long-term benefits. There is evidence that it is possible to considerably reduce fuel consumption in the short term by training or simply by telling people to drive economically. The challenge is to make the change permanent (af Wåhlberg, 2006 and 2007a).

While results reported in the literature are encouraging in terms of the potential for improved fuel consumption, it is not clear whether the overseas results will be transferable to Australia given that driving conditions, the makeup of the fleet and attitudes of Australian drivers may not be similar to those found in Europe. Research under Australian conditions is needed to provide a reliable indicator of the potential for these EcoDrive programs to reduce fuel consumption here.

3 Cement Industry Field Trail

The field trial aimed to quantify the impact of the EcoDriver training program for heavy vehicle drivers. It was conducted in conjunction with Blue Circle Southern Cement's Somerton (Melbourne) depot, which distributes powdered cement by truck to concrete batching plants throughout Victoria.

The vehicles used in the field trial were 25 metre long, 68 tonne B-doubles (Figure 1). There was no evidence from the literature review of vehicles of this size and mass being studied as part of European EcoDrive initiatives.

It was not clear from any of the EcoDrive evaluations examined in the literature review that anything other than a simple pre and post test experimental design had been employed. For this pilot study a control group was employed and the timing on the day that the training was delivered enabled two 'treatment' variants to be considered. The field trial design segmented drivers into three groups:

- Group 1 participated in the complete training programme,

- Group 2 participated in a classroom training session only, and

- Group 3 served as a control.

Figure 1 – B-double cement truck

Four drivers for each group were randomly selected from 30 drivers potentially available from the company's roster. A number of limitations were present in the design for a number of reasons, including the need to minimise the impact on the company's operations, the availability of drivers and trucks, the availability of the training staff that travelled from interstate, and the need to minimise potential confounds between the groups. These operational constraints meant there was a set of 14 candidates for selecting the eight drivers needed for groups 1 and 2 while the whole pool of 30 drivers were available for the control group (Group 3).

The training programme covered the knowledge areas as identified in the literature review. The classroom session, as undertaken by Groups 1 and 2, was conducted in a meeting room at the depot. In addition to the classroom session the drivers in Group 1 also:

- Drove a pre-set circuit accompanied by an assessor
- Received feedback on the pre-course circuit drive as part of their classroom session
- Completed a post-course drive of the same circuit with the same assessor
- Received feedback on the post-course circuit drive.

The assessor's role was solely to collect data. For the drivers in Group 1, the post-course circuit drive did not include any instruction from the assessor. From the limited information in the literature it is not clear whether drivers in the European heavy vehicle EcoDrive initiatives received instruction as part of the post-course circuit drives.

As will be described in more detail shortly, all participants from Groups 1, 2 and 3 completed circuit drives, accompanied by assessors. The assessor sat in the cab and recorded observational data on:

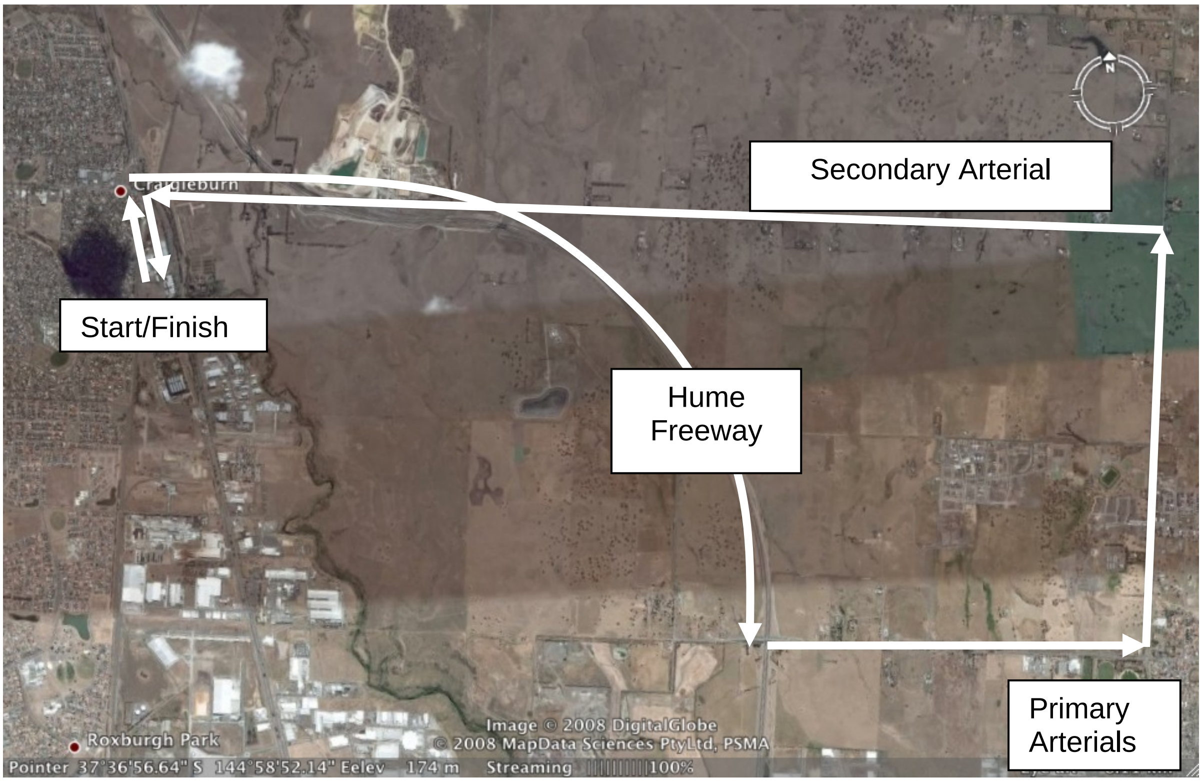
- Gear changes
- Over revving the vehicle
- Brake applications
- Scanning ahead
- Following distance

Two fully laden, almost identical trucks were made available for the field trail and were used in each of the three waves of data collection. Drivers always completed the circuit in the same truck. The two trucks had their dual fuel tanks filled at the start of the day and were then topped up with fuel at the end of each run. To ensure consistency across runs the tanks were filled to a nominated point on the inlet neck, which was checked by the same researcher each time. The time to complete the circuit was recorded for each run.

The use of two vehicles enabled data collection to be completed on a single day in each wave of the trial. The circuit drives were conducted at times of day selected to maximise the chance that the test runs could be completed under similar traffic conditions. The first run of the day began just after 9:00 a.m., and the final circuit was completed just before 3:00 p.m. The timing of vehicle runs was controlled so that the vehicles would not interact with each other when on the test circuit.

In line with the EcoDrive initiatives in Europe, specifically the Holcim (2005) cement trial in Switzerland, the circuit was about 30 km in length. It was designed to start and finish at a fuel station located near to the depot to facilitate consistent measurement of fuel consumption. The circuit (see Figure 2) reflected the outer suburban nature of the company's operations and included a section of the Hume Freeway as well as outer urban arterial roads, strip shopping areas and a segment of rural arterial. While selected specifically for the purpose of this trial the circuit came close to mimicking the route used to serve a customer to the east of the depot and also reflected operations from other depots in that freeway and highway segments were common in day-to-day operations.

Follow-up data collection was undertaken six weeks and twelve weeks after the training programme. Comparisons across and within groups are used to evaluate the impact of the programme. Table 1 summarises the activities undertaken, and the groups involved in assessment for each of the three components of the field trial. In February the Group 1 drivers completed their training and assessment. Once those activities were complete by mid-afternoon, the Group 2 drivers attended their classroom training session. In March, the drivers from each group were assessed over the 30 km test circuit. The final round of measurements in May involved only the drivers in Group 1. Group 1 drivers always drove the same vehicle in each of the data collection waves.



Source: Google Maps (maps.google.com.au)

Figure 2 – Field trial test circuit

Table 1 – Field trial schedule for training and assessment

	February 2008	*March 2008 (+ 6 weeks)*	*May 2008 (+ 12 weeks)*
Group 1: Complete training programme	• Circuit drive (with assessment) before course • Classroom training • Circuit drive (with assessment) after course	• Circuit drive (with assessment)	• Circuit drive (with assessment)
Group 2: Classroom training only	• Classroom training	• Circuit drive (with assessment)	
Group 3: Control		• Circuit drive (with assessment)	

3.1 Field trial results

Figures 3 to 6 show average results across the four drivers in each group for fuel consumption, circuit travel time, gear changes and brake applications.

On average, the fuel consumption of the drivers who completed the full course was down by about 27% (Figure 3). Importantly, they continued to achieve lower fuel consumption in the follow-up assessments conducted 6 and 12 weeks after the initial training. This suggests that the drivers retained the EcoDriving skill and knowledge over the three month period following training. In contrast to the results of the Holcim (2005) trial in Switzerland, there was no apparent deterioration in fuel economy in the post training circuit drives. Figure 3 highlights that the fuel consumption returned by the drivers who only received the classroom training was similar to the fully trained drivers before the course and also to the control drivers (who received no training). This suggests that the classroom session alone was not effective in changing driver behaviour.

There was very little variation in the average time taken to complete the circuit (Figure 4). A circuit time of 35 minutes corresponds to an average speed around the circuit of 51 km/h. That average speed is consistent with the outer suburban nature of the test circuit and the inclusion of a segment of freeway driving. As noted in the literature review, the Holcim (2005) trail in Switzerland found that speeds were improved by 9 % following training. There was no evidence of a systematic change in speeds in the current pilot. The consistency in travel times also meant that there was no major difference in traffic conditions experienced by drivers across test runs. This was as desired given that the runs had been timed to be completed outside of peak period traffic conditions.

The change in the number of gear changes and brake applications tends to follow the same trend as for fuel consumption (Figures 4 and 5). For the group 1 drivers, brake applications were down about 41 % following training while gear changes were reduced by about 29 %.

As noted above, the results reported in these figures are averages across the four drivers. Since there was variability within and across groups it is important to consider the statistical significance of the differences which were observed

The “fully trained” Group 1 drivers contributed data at four points – pre-course, immediately after the training course (on the same day), and at six and 12 weeks post-course. Accordingly their fuel consumption, number of gear changes and brake applications were analysed using a within-groups ANOVA. The main effect for reduction in fuel consumption was not statistically significant ($F(3,9)=2$; $p>0.05$), though the difference between the pre-course ($M=26.4$ litres) and immediately post-course ($M=19.2$ litres) *approached* significance according to post-hoc testing versus $p=0.05$). With the size of the reduction and the trend in direction it is likely that the addition of even one more participant would have produced a significant result.

The main effect for brake applications was significant ($F(3,9)=4.1$; $p<0.05$). According to *post-hoc* testing the difference between time 1 and time 2 (immediately before and immediately after training; $M=32.3$ vs $M=20.8$ braking episodes respectively) and between time 1 and time 3 (immediately before and 6 weeks later; $M=32.3$ vs $M=18.8$ braking episodes respectively) approached significance ($p=0.05$ in both instances). Again, one additional driver would most likely have produced a significant result for these comparisons.

The main effect for gear changes was also significant ($F(3,9)=7.9$; $p<0.01$). Post-hoc testing revealed a significant difference between time 1 and time 2 ($M=74.0$ vs $M=51.8$ changes respectively, $p<0.01$) and time 1 and time 4 (12 weeks after training) ($M=74.0$ vs $M=50.8$ changes respectively, $p<0.05$).

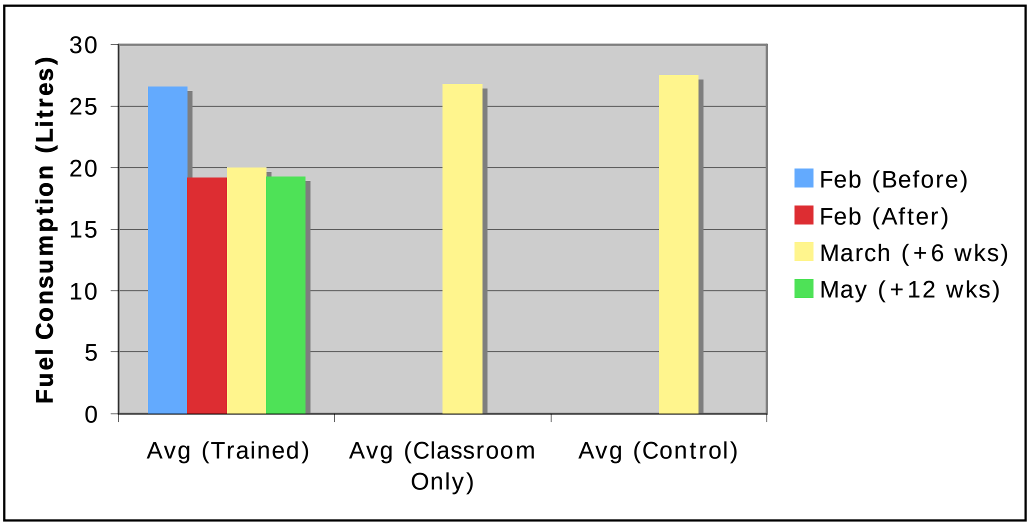


Figure 3 – Field trail results: Fuel consumption

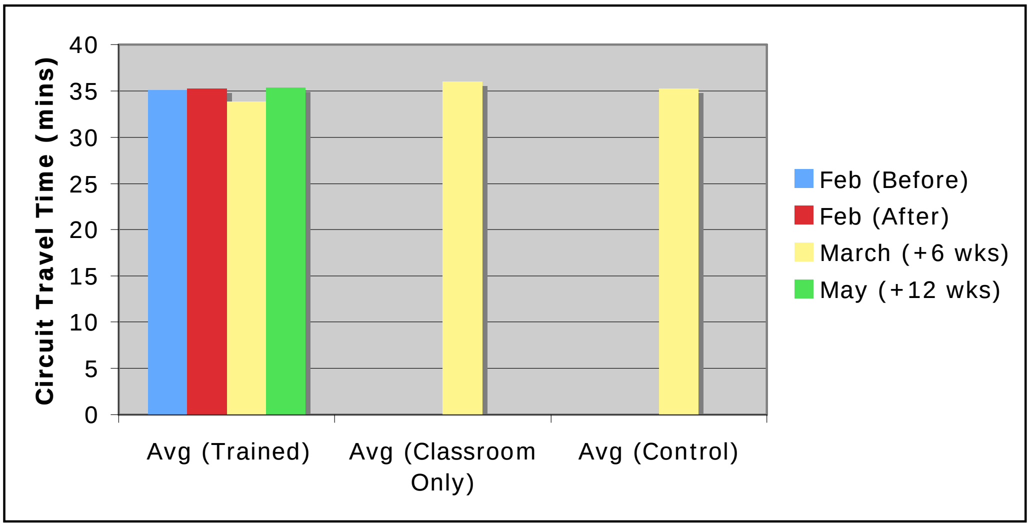


Figure 4 – Field trial results: Circuit travel time

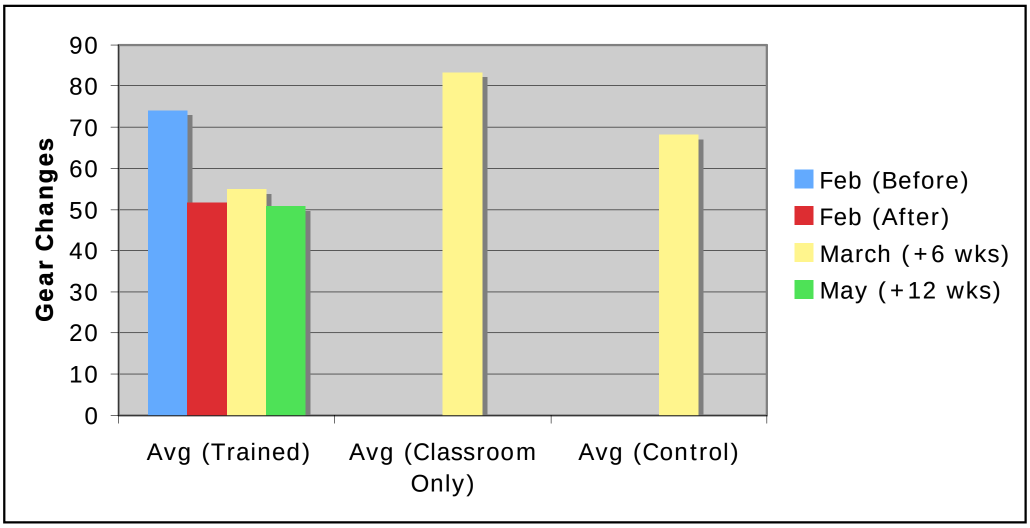


Figure 5 – Field trial results: Number of gear changes

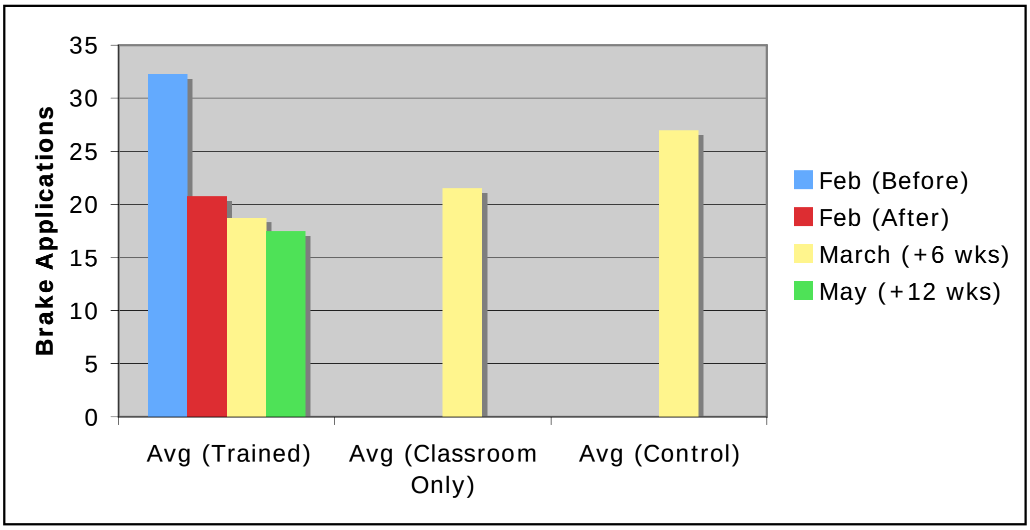


Figure 6 – Field trial results: Number of brake applications

Due to logistical constraints in terms of truck, trainer and driver availability, data was not collected for Groups 2 and 3 – the classroom training only group and the control group respectively – on the day of training. Their data can be compared using a between-groups ANOVA for each of the dependent variables at time 3 (6 weeks post training) however. The difference in fuel consumption was significant ($F(2,9)=7$; $p<0.05$) such that Group 1 differed from both the classroom and control groups ($M=20.1$ litres vs $M=26.8$ litres, $p<0.05$ and $M=20.1$ litres vs $M=27.5$ litres, $p<0.01$ respectively). However, the classroom group did not differ from the control group ($M=26.8$ litres vs $M=27.5$ litres, $p>0.05$).

The difference in brake applications at time 3 was not significant ($F(2,9)=3.5$; $p>0.05$), though post-hoc testing revealed a statistically significant difference between Group 1 and the control group ($M=18.8$ applications vs $M=27.0$ applications).

A comparison of gear changes though did produce a significant result ($F(2,9)=7$; $p<0.05$), driven only by a significant difference between Group 1 and the Group 2 ($M=55.0$ changes vs $M=83.3$ changes, $p<0.01$).

Taken together, overall the fully trained group did perform better than either the control group or the classroom session only group, indicating a benefit for the training. However, given that the classroom-only group was similar in their performance to the control group it would seem that the presenting the information in this manner was not sufficient. Perhaps having the assessed drive immediately prior to the course enables the better transfer of information and/or the drive immediately after allows the opportunity to immediately try the techniques just learned. In an ideal training situation the ride-along assessor would provide feedback and suggestions in the post drive to consolidate the learning. With two assessors however, this was not undertaken in this instance, which would serve to make the comparison of results more conservative.

Significant variability exists in each of the three dependent variables, working against the potential for significant results, the direct result of such a small sample size. The magnitude of the changes coupled with the consistent trends in the data and the likely improvement with even small increases in group size warrant a larger trial to follow up the current pilot.

4 Conclusions

The pilot field trial described here was designed to test EcoDriver training under Australian conditions. The results are encouraging and suggest that the EcoDriver skills have been retained by those drivers who received the full training course and that those drivers have been able to achieve lower fuel consumption than other drivers who have not received the full training.

The results of the field trial need to be interpreted with caution. It is important to keep in mind key parameters of this trial, namely that it involved large, heavy vehicles; an outer metropolitan operation and at the time when measurements were made, the driver was accompanied by an on-board assessor. Despite those unique features of this pilot, the magnitude of the reductions in fuel consumption and the retention of the EcoDriving skill by the trained drivers suggest that this form of training could have a valuable role to play in reducing vehicle fuel consumption and related emissions.

The research reported here has the potential to be extended to quantify the impacts of EcoDriving on fuel consumption, emissions, operating costs and safety. Valuable insight would be obtained from evaluations conducted in a naturalistic setting since there would be scope to assess whether the results obtained here transfer to other vehicle types, other operating environments and into day–to-day operations. Additional research could also seek to develop the business case for EcoDriver training where benefits could arise from reductions in operating and maintenance costs as well as potentially in the value of carbon credits which might accrue from reducing emissions through this form of initiative.

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